

Comparison of Aerosol Optical Depth and Ångström Exponent Retrieved by AERONET, MISR, and MODIS Measurements



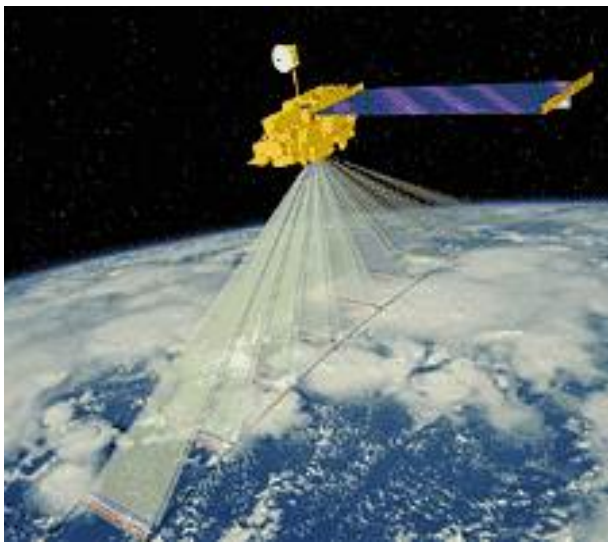
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Abstract. Aerosol measurements are conducted worldwide in order to identify the impact of aerosols on Earth's radiation balance and its local and global climate. Aerosols are fine solid particles or liquid droplets suspended in the air, with diameters ranging from a few nanometers through a few tens of micrometers. They differ in size, shape, composition, and lifetime, depending on their origin and subsequent atmospheric processing. There are various approaches to aerosol measurements, e.g., ground-based or satellite observations. In this study, we combine satellite measurements obtained by the Multiangle Imaging SpectroRadiometer (MISR) and Moderate Resolution Imaging SpectroRadiometer (MODIS) instruments, respectively, and data from selected stations of the worldwide ground-based Aerosol Robotic Network (AERONET) in order to compare the Ångström exponent (AE) and aerosol optical depth (AOD) at a wavelength of 550 nm. We used AERONET measurements as our frame of reference. Four major aerosol types were investigated: urban-industrial, biomass burning, desert dust and maritime. The results show that MISR and MODIS data demonstrate systematic and significant differences in AE and AOD values with respect to AERONET observations. We attribute these differences between AERONET data and satellite MODIS and MISR data to spatial and temporal sampling procedures as well as model assumptions and retrieval algorithms of satellite data.

Analysis. This investigation focuses on assessing the accuracy of MODIS/MISR data retrievals and determines trends in satellite data retrieval errors. The data retrieved by MODIS and MISR are frequently in contravention with direct measurements from AERONET, which provide the accepted values for AOD and AE. Previous analyses have shown trends of overestimation or underestimation of AOD in the satellite data (e.g., Kahn et al., 2010). Thus, we compare and contrast MISR- and MODIS-retrieved aerosol optical depth (AOD) and Ångström exponent (AE) values with coincident AERONET sky-scan results at a wavelength of 550 nm. Furthermore, we investigate whether there are seasonal patterns in AOD and AE observations. We use a statistical approach in order to find the significance of such trends or patterns for AOD and AE differences for four aerosol categories. We display our results for the trends of AOD and AE in absolute values as well as in terms of the standard deviation σ in order to demonstrate the significance of the outcome. The time span covers data from years 2000 through 2008.

Data Selection. Four aerosol types were investigated: urban-industrial, biomass burning, desert dust, and maritime. The stations are selected for the expected dominant aerosol types and their geographic diversity and well-populated data records during the analysis period.

Stations used in this Study			
Urban-Industrial	Biomass Burning	Desert Dust	Maritime
GISS	Abraços Hill	Abu Dhabi	Azores
GSFC	Alta Floresta	Bahrain	Bermuda
Philadelphia	Campo Grande Sonda	Nes Ziona	Mauna Loa
Los Angeles-UCLA	Cuiaba Miranda	Ras El Ain	Coconut Island
Mexico City	Ceila-BA	Dakar	Midway Island
Toulouse	Cordoba-CETT	Dahkla	Laina
Paris	Mongu	Izana	Nauru
Ispra	Petrolina Sonda	Capo Verde	Tahiti
Rome	Arica	Dalanzadgad	Dunedin
Cairo	Senanga	Saada	
Minsk		Daihu	
Beijing			
Shirahama			

Table 1: Summary of the selected locations of 43 AERONET sites used in this study: urban-industrial (13), biomass burning (10), desert dust (11), maritime (9). The study investigates data over an 8 years time interval from 2000 through 2008.

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Analysis Approach. The AE vs. AOD scatter plot is a common tool to display aerosol types. While AE gives information about the aerosol size, AOD is related to the aerosol loading. Figure 1 shows scatter plots for the four investigated aerosol types for both MISR and AERONET data. MODIS/AERONET scatter plots display similar patterns and are therefore not shown here. Each aerosol type shows a characteristic data distribution pattern, with similar distributions for MISR and AERONET observations. However, for each aerosol type, there are nevertheless remarkable differences in the AERONET and MISR data distribution.

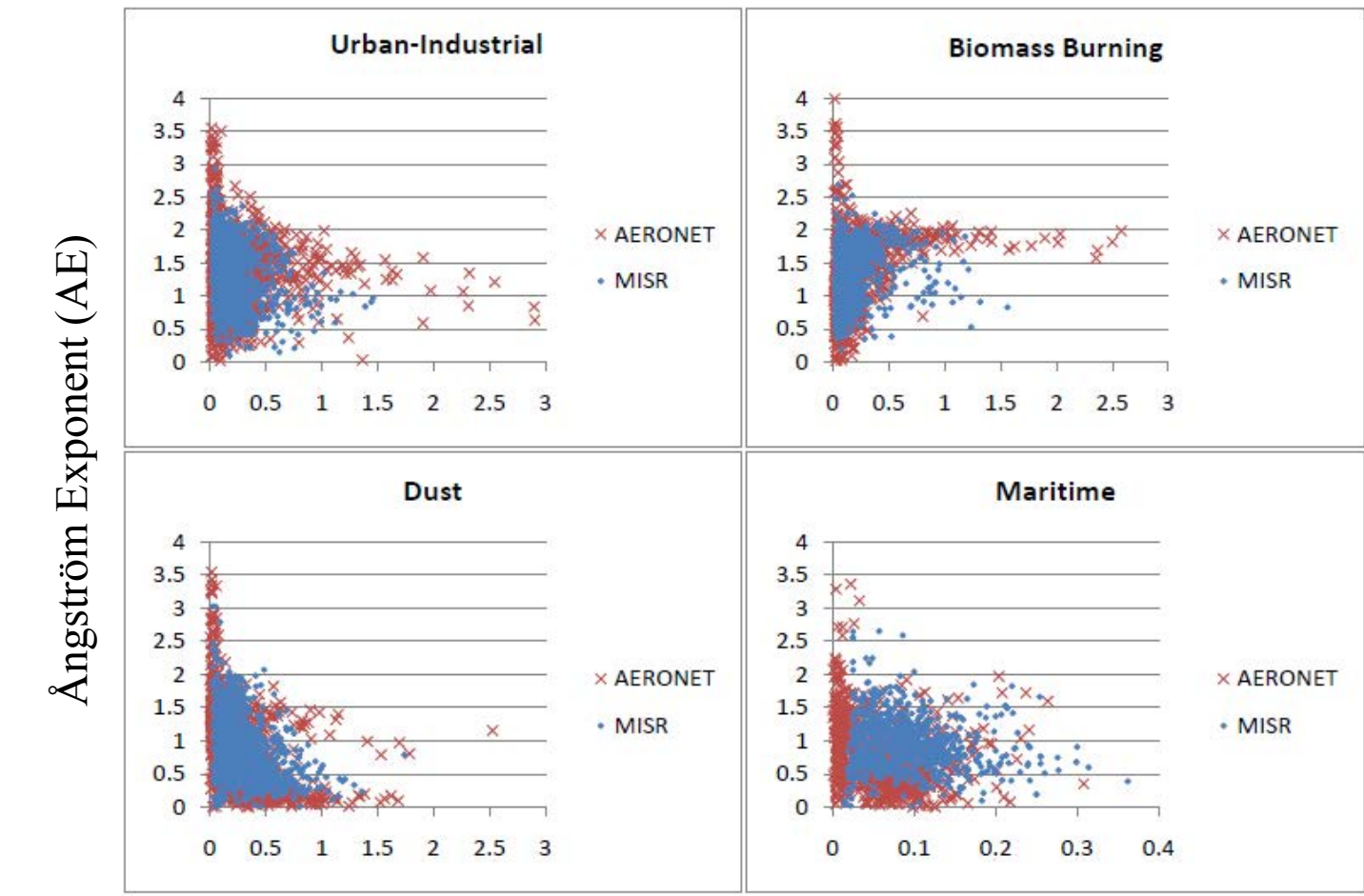


Figure 1. AE vs. AOD scatter plots

Further analysis reveals trends in the MISR and MODIS AOD, respectively, and AERONET AOD values (Fig.2), specifically for urban-industrial, biomass burning, and desert dust data. The scatter plots clearly suggest opposite trends with respect to AERONET AOD.

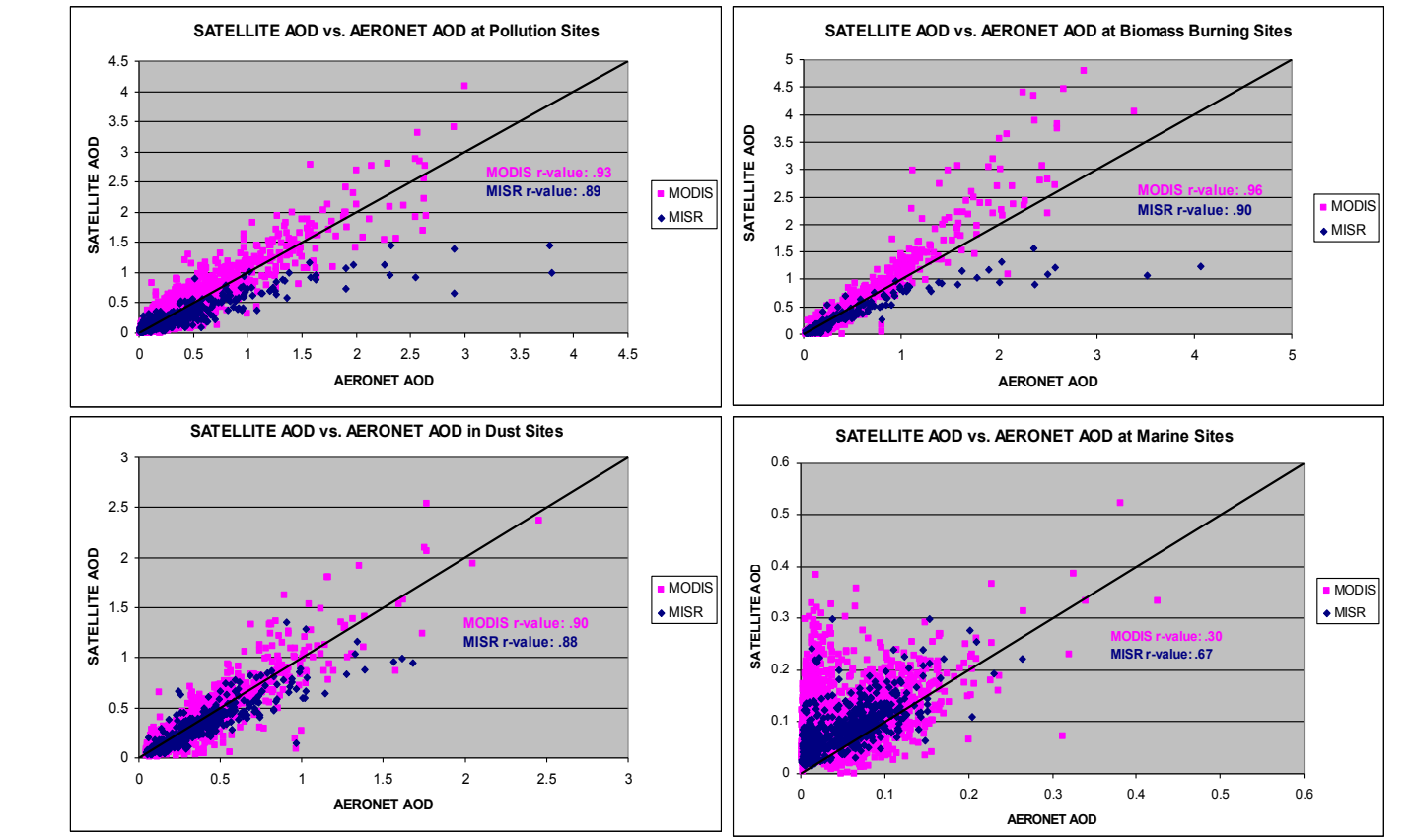


Figure 2. Comparisons of the satellite retrieved MISR/MODIS AOD and AERONET AOD, which is represented by the full line.

Results. The MISR-AERONET and MODIS-AERONET data sets analyzed in this study clearly exhibit statistically significant differences for both MISR and MODIS retrieved AOD and AE data for all investigated aerosol types. These differences cannot be attributed to data outliers, since about 95% of the covered data contribute to the discrepancies. Figure 3 displays the range of differences for MISR and AERONET AE values. MISR clearly overestimates small particles and underestimates bigger particles. A similar scenario is given for MODIS retrieved AE (Fig. 5). In Figure 4, differences between MISR and AERONET AOD are shown. In this case, MISR underestimates AOD with respect to higher AERONET AOD and

overestimates AOD with respect to smaller AERONET AOD. Generally, MODIS AOD measurements seem to be more reliable (Fig.6).

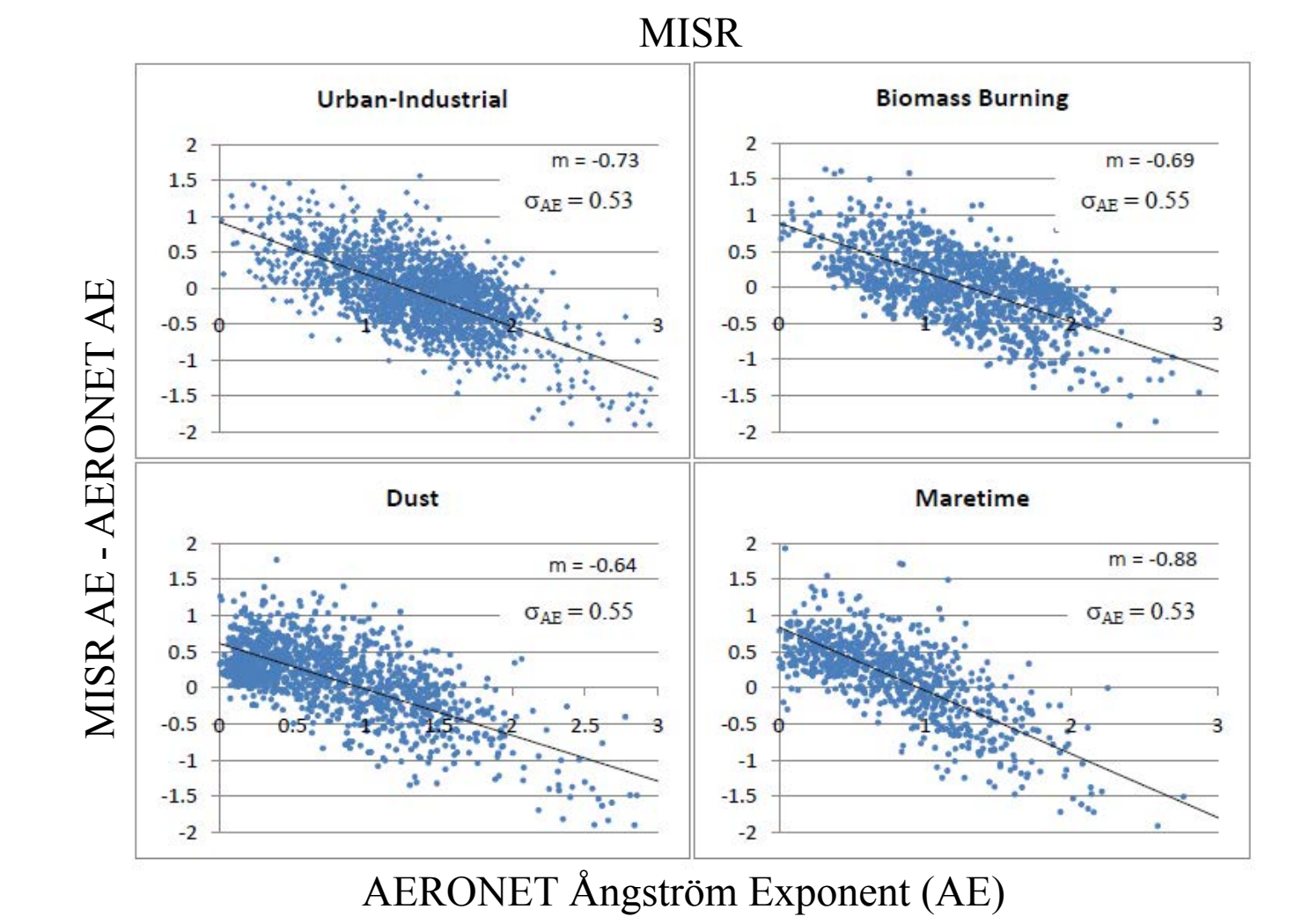


Figure 3. Difference of MISR and AERONET AE vs. AERONET AE

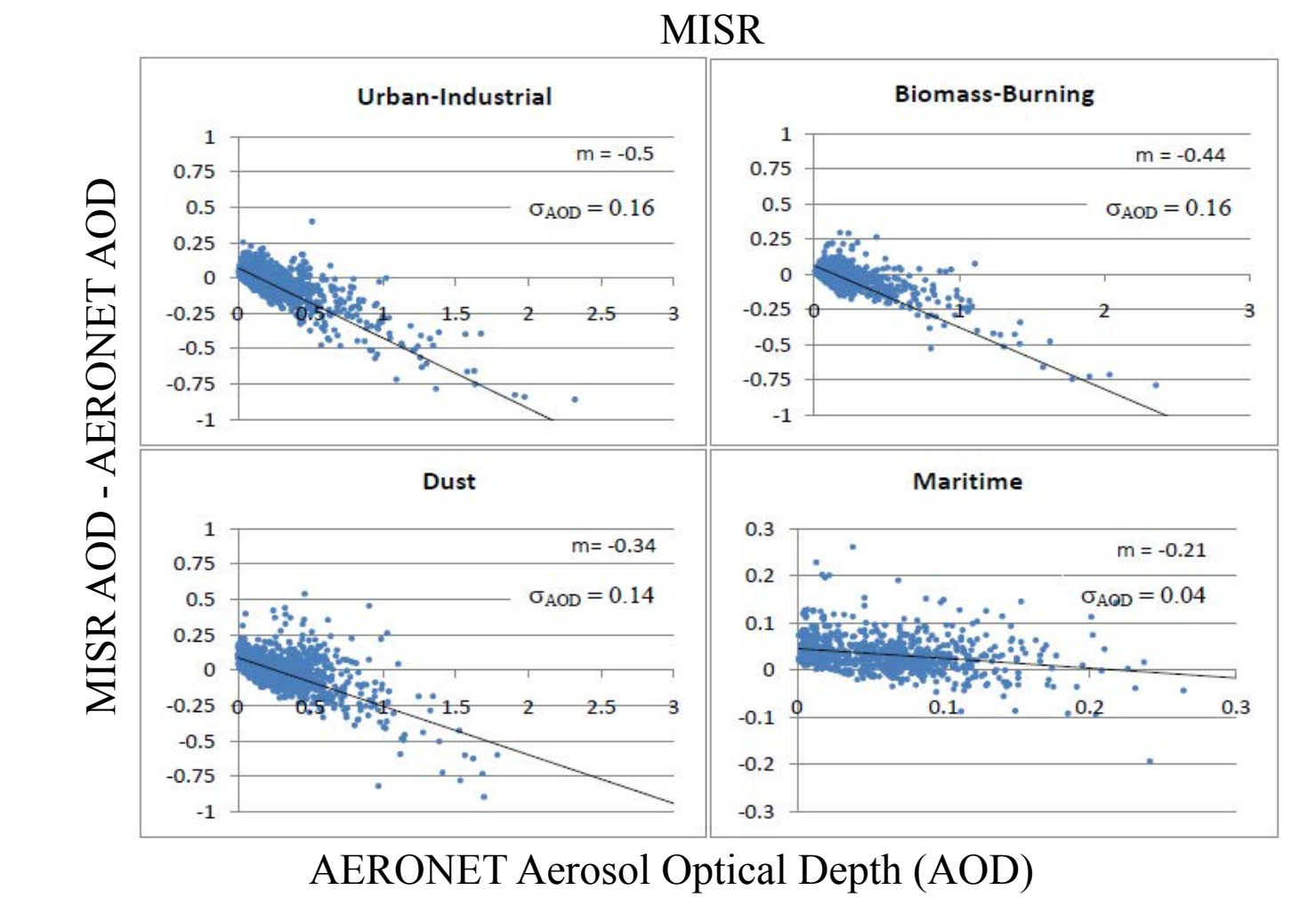


Figure 4. Difference of MISR and AERONET AOD vs. AERONET AOD

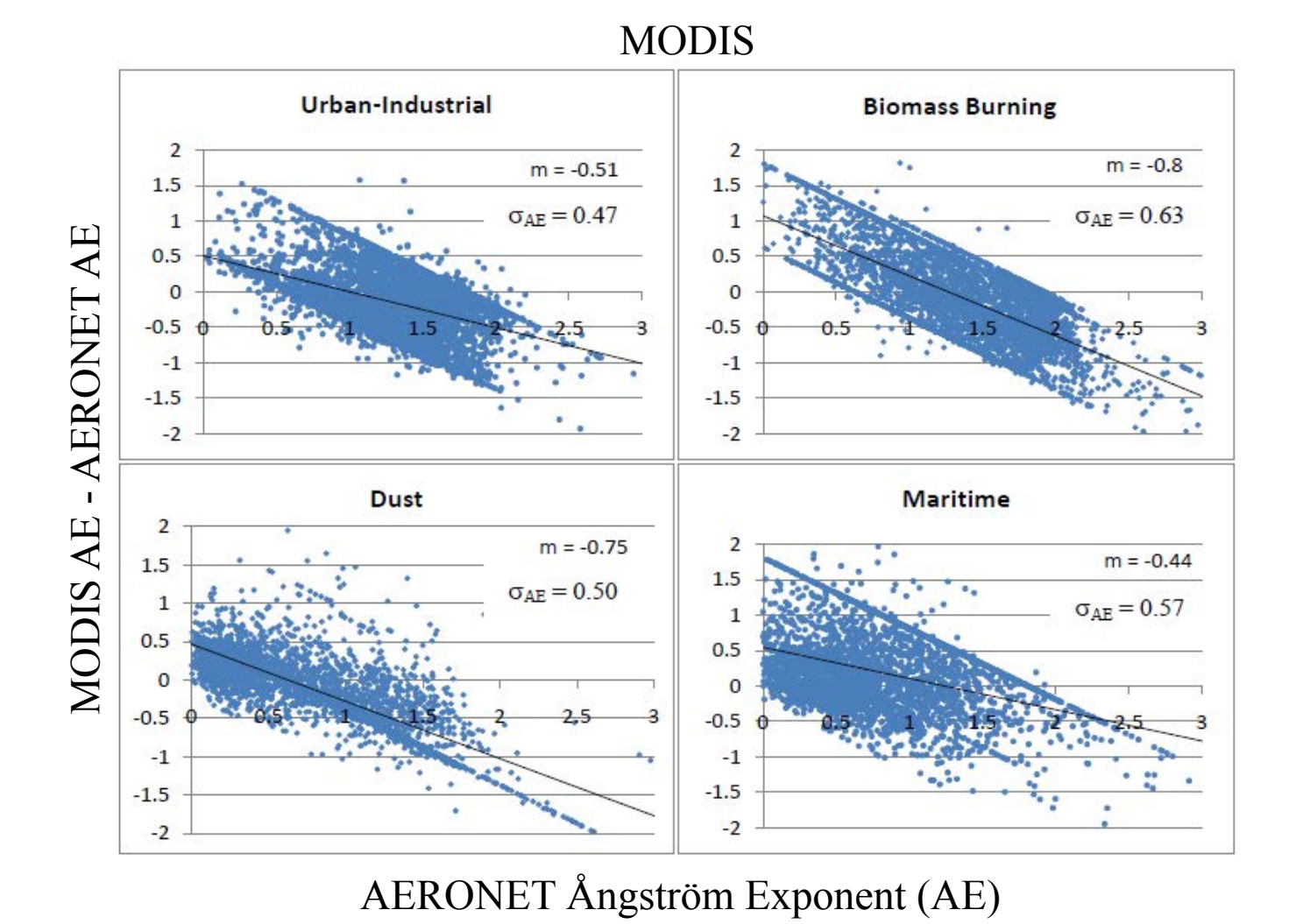


Figure 5. Difference of MODIS and AERONET AE vs. AERONET AE

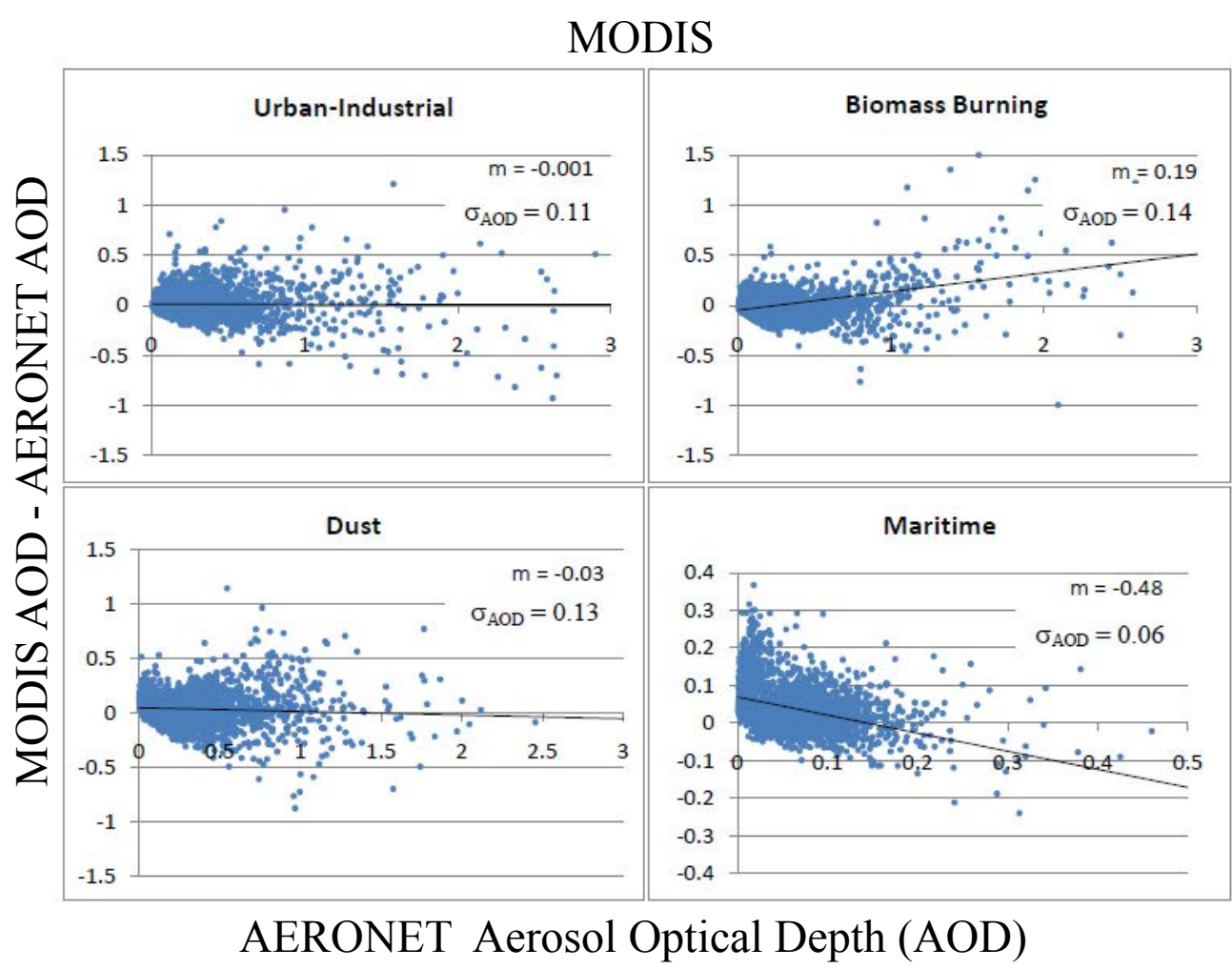


Figure 6. Difference of MODIS and AERONET AOD vs. AERONET AOD

Significant differences were found for MISR and MODIS seasonal dependent AOD values. For urban-industrial and biomass burning aerosol types MODIS clearly overestimates AOD with respect to MISR data. No significant variation in difference were found for desert dust and maritime aerosol. No significant differences were found in seasonal AE variations.

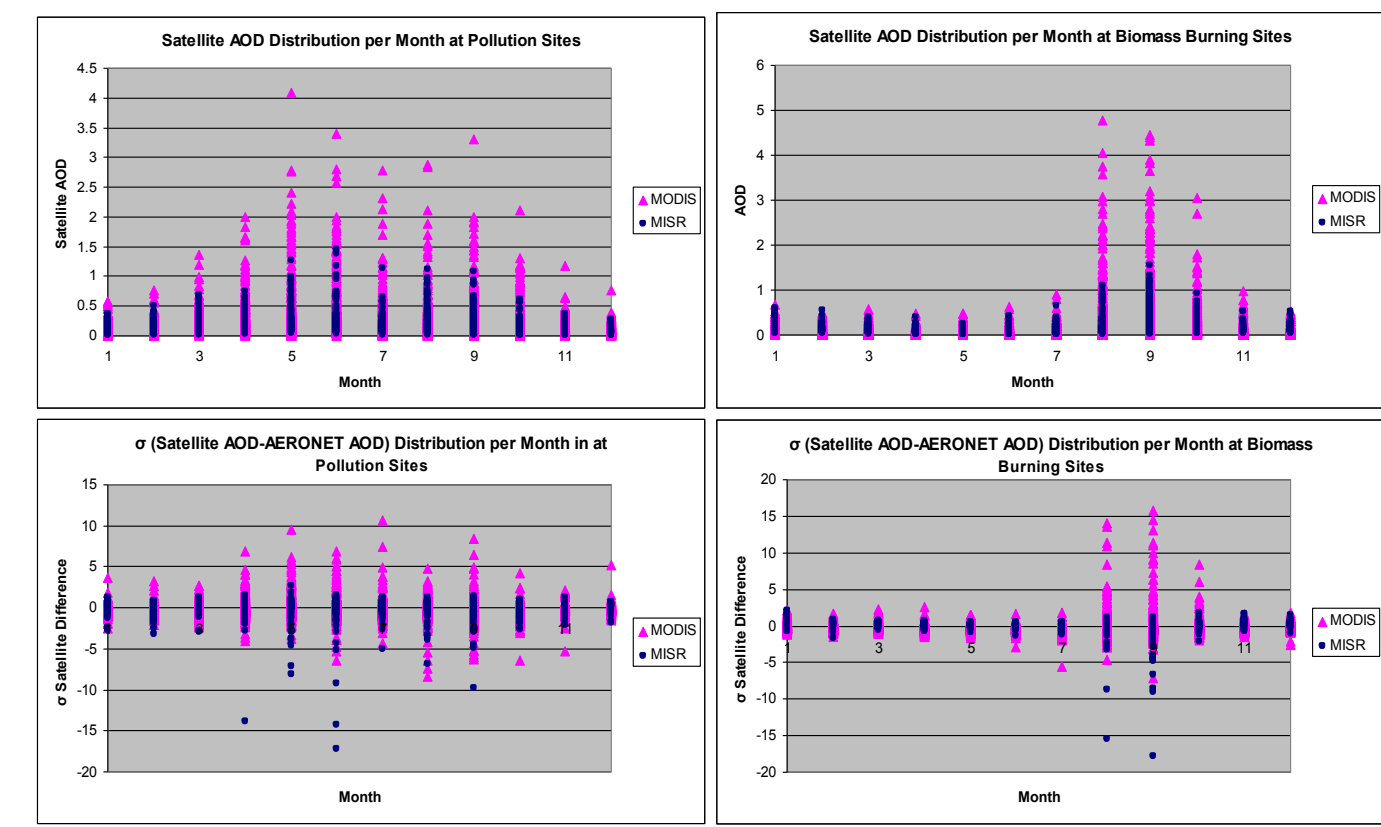


Figure 7. MISR and MODIS seasonal AOD. Shown is the absolute AOD (top), and the difference in terms of standard deviation σ (bottom).

Conclusion/Future Research. There are significant differences of MISR, MODIS, and AERONET AOD and AE. This can be attributed to spatial and temporal sampling procedures as well as model assumptions and retrieval algorithms of satellite data. Future studies should include continental and hybrid aerosol types, clear odd data from MODIS AOD and AE retrievals, expand the statistical procedure used here to other wavelengths, include more stations, restrict the study to AOD values $AOD > 0.05$ and $AOD < 2$, use specific events (e.g., volcanic eruptions) in order to verify the outcome found in this study

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